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(71)Applicant : **SEKISUI CHEM CO LTD**

(72)Inventor : **UEHARA TAKESHI**
YARA TAKUYA

(30)Priority

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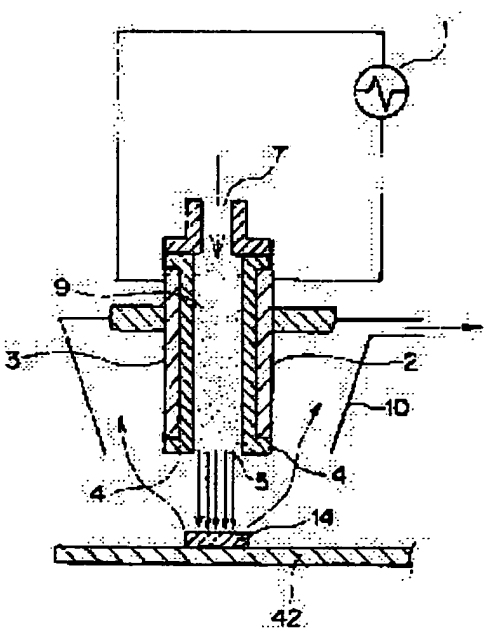
(54) DISCHARGE PLASMA PROCESSING METHOD AND APPARATUS THEREOF



(57)Abstract:

PROBLEM TO BE SOLVED: To provide a discharge plasma processing method and an apparatus therefor which can realize a stable discharge state under the atmospheric pressure condition and treat circuit boards with a small quantity of process gas, using a simple and convenient apparatus.

SOLUTION: The discharge plasma processing method and the apparatus thereof are characterized, by setting a solid dielectric on at least one opposite surface of a pair of opposed electrodes under a pressure near the atmospheric pressure, introducing a process gas between the opposed electrodes, applying a pulse-like electric field to obtain a plasma, and exposing a circuit board to the plasma.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] Especially this invention relates to the discharge plasma treatment approach of the circuit board, and its equipment about the discharge plasma treatment approach.

[0002]

[Description of the Prior Art] What is depended on the dry process which generates the glow discharge plasma by the pressure of 1.333 to 1.333x104Pa as the surface treatment approach of solid-states, such as plastics, is known widely. By this approach, if a pressure exceeds 1.333x104Pa, since discharge becomes local, it will shift to arc discharge and application to a heat-resistant scarce plastic plate will become difficult, it is required to process under the low voltage of 1.333 to 1.333x104Pa.

[0003] Since a mass vacuum housing and high power evacuation equipment are needed when a vacuum chamber, evacuation equipment, etc. must be installed, and the above-mentioned surface-preparation approach becomes what has expensive surface-preparation equipment and processes a large area substrate by this approach, since the processing in low voltage is needed, surface-preparation equipment will become still more expensive. Moreover, since vacuum suction takes long duration in performing surface treatment of the high plastic plate of absorptivity, it also has problems, like a processing article becomes cost quantity.

[0004] The thin film formation approach of having used the thin line mold electrode is indicated by JP,2-48626,B. This thin film formation approach forms a thin film on a substrate by mixing inert gas, fluorine-containing gas, and monomer gas, such as helium, and supplying the glow discharge plasma region near the substrate from the perforated pipe which has two or more puncturing.

[0005] Since this thin-film-fabrication approach generates the glow discharge plasma

in atmospheric pressure, low-cost-izing of equipment or a facility is possible for it, and the processing of a large area substrate of it is also attained. However, since the monotonous mold electrode or the curved-surface-like electrode is used together inside the processing container by this thin-film-fabrication approach, much more simplification is possible for this equipment. However, since the magnitude and the configuration of a base material are restrained in the present condition, it is not easy to carry out surface treatment of the location of arbitration.

[0006] The base material surface treatment equipment which holds the mixed gas which becomes inter-electrode [in which the solid dielectric was arranged] from rare gas and the gas for processing in the ** style condition to an one direction, and is made to generate the discharge plasma is indicated by JP,5-275193,A. However, since this surface treatment equipment is equipment made to generate the discharge plasma in the state of the atmospheric pressure of a open system, when losing the effect of the open air, contacting the discharge plasma on a base material front face and performing desired surface treatment, it needs to pass mixed gas at high speed, must continue passing the gas of a large flow rate, and cannot say it as satisfying surface treatment equipment.

[0007] Moreover, the plasma cleaning approach is indicated by JP,9-148095,A and JP,10-107062,A as an approach of removing the dirt of a bonding pad as a method of cleaning the circuit board. However, in this approach, it has problems, like a vacuum chamber, evacuation equipment, etc. are required, surface cleaning treatment equipment will become expensive like the above, and a processing article becomes cost quantity.

[0008]

[Problem(s) to be Solved by the Invention] This invention can realize the discharge condition stabilized under atmospheric pressure conditions in view of the above, and offers the discharge plasma treatment approach which can process the circuit board, and its equipment by simple equipment and the little gas for processing.

[0009]

[Means for Solving the Problem] this invention person completed a header and this invention for the ability of the circuit board to be processed simple, when the discharge plasma treatment equipment which can realize the discharge condition stabilized under atmospheric pressure conditions as a result of inquiring wholeheartedly in view of the above-mentioned technical problem was used.

[0010] That is, invention of the 1st of this invention is the discharge plasma treatment approach of the circuit board characterized by contacting the plasma acquired by installing a solid dielectric in one [at least] opposed face of the electrode of the pair which counters, introducing raw gas between the counterelectrodes of the pair concerned, and impressing pulse-like electric field under the pressure near the atmospheric pressure to the circuit board.

[0011] Moreover, the pulse-like electric field of invention of the 2nd of this invention are the discharge plasma treatment approaches according to claim 1 that a pulse standup and/or falling time amount are characterized by field strength being 1 - 250 kV/cm 100 or less microseconds.

[0012] Moreover, the pulse-like electric field of invention of the 3rd of this invention are the discharge plasma treatment approaches given in invention of the 1st or 2 to which a frequency is characterized by 0.5-100kHz and pulse length being 1 - 1000 microseconds.

[0013] Moreover, invention of the 4th of this invention is the discharge plasma treatment approach given in the 1-3rd ones which are characterized by being made as

[draw / the plasma generated between counterelectrodes / from a gas diffuser nozzle / toward a base material] of invention.
[0014] Moreover, invention of the 5th of this invention arranges the solid dielectric container which equipped the electrode of 1 with the gas diffuser. Make the gas diffuser concerned counter, prepare other electrodes, and the circuit board is arranged between the gas diffuser concerned and other electrodes. At the same time it makes the gas for processing discharge continuously from the gas diffuser concerned It is the discharge plasma treatment approach of generating the discharge plasma by impressing electric field to inter-electrode. the electrode concerned of 1 -- being concerned -- others -- The pulse-like electric fields impressed to inter-electrode are build up time and 100 or less microseconds of falling time amount, and the discharge plasma treatment approach of the circuit board characterized by being field strength 1 - 100 kV/cm.
[0015] Moreover, invention of the 6th of this invention is the discharge plasma treatment approach given in the 1-5th ones to which the circuit board is characterized by being a resin plate for the circuit boards of invention.
[0016] Moreover, it is discharge plasma treatment equipment for circuit board processing characterized by invention of the 7th of this invention coming to have the device which introduces raw gas between the counterelectrode of a pair with which the solid dielectric was installed in one [at least] opposed face, and the counterelectrode of the pair concerned, the device in which pulse-like electric field are impressed to this inter-electrode one, and the device in which the plasma acquired by this pulse electric field is contacted to the circuit board.
[0017] Moreover, invention of the 8th of this invention is discharge plasma treatment equipment given in the 7th invention characterized by being made as [draw / the plasma to which the device in which the circuit board was made to contact generated the plasma between counterelectrodes / from a gas diffuser nozzle / toward a base material].
[0018] Moreover, the electrode of 1 with which the solid dielectric container with which invention of the 9th of this invention was equipped with the gas diffuser was arranged, And have other electrodes which countered the gas diffuser concerned and were prepared, and it is made as [make / the gas for processing / discharge continuously from the gas diffuser concerned]. the electrode concerned of 1 -- being concerned -- others -- it is discharge plasma treatment equipment for circuit board processing characterized by being made as [impress / to inter-electrode / the pulse-like electric field build up time and whose falling time amount are 100 or less microseconds and, whose field strength is 1 - 100 kV/cm].
[0019] Moreover, it is discharge plasma treatment equipment given in the 9th invention to which, as for invention of the 10th of this invention, specific inductive capacity [container / solid dielectric] under 25-degree-C environment is characterized by consisting of the ten or more quality of the materials.
[0020]
[Embodiment of the Invention] This invention is the discharge plasma treatment approach and equipment of the circuit board which contact the discharge plasma acquired by installing a solid dielectric in one [at least] opposed face of the electrode of the pair which counters, introducing raw gas between the counterelectrodes of the pair concerned, and impressing pulse-like electric field to this inter-electrode one under the pressure near the atmospheric pressure to the circuit board in the art in the semi-conductor production process by plasma treatment. This invention is explained below at a detail.

[0021] The circuit board is arranged in the discharge space of the plasma which generates the plasma as a means to make the circuit board contact, in inter-electrode [which carries out (1) opposite], for example, and there are a method of contacting the plasma to the circuit board and a method (gun mold) of contacting it toward the circuit board arranged outside discharge space, as the plasma generated in inter-electrode [which carries out (2) opposite] is drawn.
[0022] As the concrete approach of the above (1), the circuit board is arranged to the parallel monotonous mold inter-electrode covered with the solid dielectric. Are the approach of making the plasma contacting and the up electrode which has many holes is used. The approach of processing with the shower-like plasma, the method of making it run the circuit board, and the container-like solid dielectric that has a diffuser nozzle in one electrode are prepared, and the approach of spraying on the circuit board which has arranged the plasma on other electrodes from this nozzle etc. is mentioned.
[0023] Moreover, as the concrete approach of the above (2), a solid dielectric is extended, the plasma induction nozzle is formed, the approach of spraying towards the circuit board arranged outside discharge space etc. is mentioned, and the combination of an parallel monotonous mold electrode, a long mold nozzle and a coaxial-circles telescopic electrode, and a cylindrical nozzle can be used. In addition, the quality of the material at the tip of a nozzle does not necessarily need to be a solid dielectric, and a metal etc. is sufficient as it as long as it has taken the above-mentioned electrode and the insulation.
[0024] The circuit board is arranged in the discharge space of the plasma generated in inter-electrode [which the approach of the above (1) counters], and how to contact the plasma to the circuit board is explained, referring to a drawing. Drawing 1 is drawing showing the cross section of an example of the discharge plasma treatment equipment of this invention. One expresses among drawing a power source and the fixture with which in an electrode and 4 a gas diffuser and 7 connect the gas inlet for processing, and, as for 8, a solid dielectric container and 5 connect [2 and 3] an electrode, and 14 expresses the circuit board, respectively.
[0025] In this invention, it is in the condition that the gas for processing was introduced into the solid dielectric container 4, and the discharge plasma is generated in the solid dielectric container 4 interior by impressing electric field between an electrode 2 and an electrode 3. The gas of the solid dielectric container 4 interior blows off from the gas diffuser 5 towards the circuit board 14, the component of the gas for processing excited by the plasma state contacts the front face of the circuit board 14, and processing of the circuit board is made. Therefore, the relative position of the solid dielectric container 4 and the circuit board 5 can be changed, the processing location of the circuit board can be changed, and processing of the large area circuit board and partial assignment processing are attained by simple equipment and the little gas for processing.
[0026] Especially as a configuration of an electrode 2 and an electrode 3, it is not limited but curved-surface mold configurations, such as cylindrical and a solid sphere mold, etc. are mentioned other than the monotonous mold configuration of illustration. An electrode 2 and an electrode 3 may consist of a metal of multicomponent systems, such as stainless steel and brass, and may consist of pure metals, such as copper and aluminum.
[0027] Although the distance which passes along the interior of the solid dielectric container 4 and the core of the gas diffuser 5 from the core of an electrode 2, and results in an electrode 3 is suitably determined by the magnitude of the thickness of

the solid dielectric container 4, the quality of the material, the thickness of the circuit board 14 and the quality of the material, and applied voltage etc., it is 0.5-30mm preferably. If it exceeds 30mm, the high voltage is needed, a discharge condition will become easy to shift to arc discharge, and uniform surface treatment will become difficult.

[0028] It is not limited especially as a configuration of the solid dielectric container 4 used by this invention, for example, a rectangle, cylindrical, and spherical ** are mentioned.

[0029] As the quality of the material of the solid dielectric container 4, multiple oxides, such as metallic oxides, such as plastics, such as polytetrafluoroethylene and polyethylene terephthalate, glass, a silicon dioxide, an aluminum oxide, a zirconium dioxide, and a titanium dioxide, and barium titanate, etc. are mentioned, for example.

[0030] If the solid dielectric whose specific inductive capacity under 25-degree-C environment is ten or more things is used especially, the discharge plasma of high density can be generated by the low battery, and processing effectiveness will improve. Although especially the upper limit of specific inductive capacity is not limited, with an actual ingredient, its about 18,500 thing is available and can use it for this invention. Specific inductive capacity is the solid dielectric of 10-100 especially preferably. As an example of the solid dielectric which is ten or more, the above-mentioned specific inductive capacity can mention multiple oxides, such as metallic oxides, such as a zirconium dioxide and a titanium dioxide, and barium titanate.

[0031] The titanic-acid compound is known as a ferroelectric. Specific inductive capacity changes with the crystal structures, and it is about 80 specific inductive capacity in the rutile mold crystal structure of TiO2 simple substance. Specific inductive capacity is about 2,000-18,500, and it can be made to change with purity or crystallinity with the compound of the oxide of metals, such as Ba, Sr, Pb, calcium, Mg, and Zr, and TiO2.

[0032] On the other hand, in a case independent [above-mentioned / TiO2], since the presentation change by heating is sharp, if an operating environment is not restricted or it is not based on the special coat formation approach, a coat with a suitable specific resistance value is not obtained, but there is fault, like a discharge condition becomes unstable. For this reason, it is better for the TiO2 independent twist to also have made aluminum 2O3 contain, and to use it. Since the mixture of TiO2 and aluminum 2O3 is thermally stable, a practical use top is also suitable for it. Preferably, it is the metallic-oxide coat mixed with 5 - 50 % of the weight of titanium oxide, and 50 - 95 % of the weight of aluminum oxides. It is it easy to generate arc discharge that the rate of an aluminum oxide is less than 50 % of the weight, and when it exceeds 95 % of the weight, high applied voltage is needed for discharge plasma generating. Specific inductive capacity becomes ten to about 14, specific resistance becomes about 1010, and such a coat is suitable as the quality of the material of the solid dielectric container of this invention.

[0033] Moreover, when the above-mentioned zirconium dioxide is independent, specific inductive capacity is about about 12, and is advantageous to generating the discharge plasma on a low electrical potential difference. Usually, a zirconium dioxide adds yttrium oxide (Y2O3), a calcium carbonate (CaCO3), a magnesium oxide (MgO), etc. within 30 % of the weight, prevents expansion by crystal transformation, and contraction, is stabilized, and can use these also in this invention. Specific inductive capacity is determined by the crystallinity of the class metallurgy group oxide of an additive. In this invention, what the zirconium dioxide contained at least 70% of the weight is desirable. For example, specific inductive capacity

becomes eight to about 16, and is suitable for the zirconium dioxide coat with which the oxidization yttrium was added four to 20% of the weight as a solid dielectric of this invention.

[0034] The solid dielectric container 4 has that desirable in which the electrode 2 is arranged. Drawing 2 and 3 are drawings showing the example of arrangement of an electrode 2 and the solid dielectric container 4. An electrode 2 may be arranged in fields other than the field in which the gas diffuser 5 is formed when the solid dielectric container 4 is a rectangle. As the field of the solid dielectric container 4 in which an electrode 2 is arranged being thick, 0.03-30mm is desirable. When it is less than 0.03mm, dielectric breakdown may happen at the time of high-voltage impression, and arc discharge may arise.

[0035] The thing equipped with a gas inlet 7 and the gas diffuser 5 of the solid dielectric container 4 is desirable. The thing of the shape of what is not limited, for example, consists of a slit-like thing and many holes especially as a configuration of the gas diffuser 5, and a tip which the above-mentioned solid dielectric container forms etc. is mentioned. Drawing 4 , and 5 and 6 are drawings showing the example of the gas diffuser 5. Moreover, the solid dielectric container itself may have gas storage ability in addition to the gestalt equipped with the gas inlet which shows the solid dielectric container of this invention to drawing 1 .

[0036] The fixture 8 of drawing 1 can change spacing of an electrode 3 and the gas diffuser 5 free. When it can move continuously, surface treatment can be carried out and it processes a part of circuit board 14 with a fixture 8, holding spacing of an electrode 3 and the gas diffuser 5 uniformly when the circuit board 14 is a large area-like object, spacing of an electrode 3 and the upper SU diffuser 5 can be changed free, and continuous surface treatment, partial surface treatment, etc. can be carried out. However, if spacing between the gas diffuser 5 and the circuit board 14 is too long, since the probability to contact air will become high and processing effectiveness will fall, cautions are required.

[0037] How (gun mold) to contact it toward the circuit board arranged outside discharge space as the plasma generated in inter-electrode [which the approach of the above (2) counters] is drawn is explained by a diagram.

[0038] Drawing 7 is drawing showing an example of the equipment which sprays plasma gas on a base material using the cylindrical solid dielectric which offered the gas diffuser, the equipment which prepared gas suction opening of the shape of a doughnut prepared in the perimeter of a gas diffuser nozzle, and equipment equipped with the conveyance device of a base material. 1 -- an electrode and 2 -- a ground electrode and 3 -- an inside electrode and 4 -- in a raw gas inlet and 10, an exhaust gas cylinder and 14 express the circuit board, and 41-43 express [a solid dielectric and 5 / a gas diffuser and 7] a conveyance belt, respectively. For example, raw gas is introduced in the direction of a void arrow head in a tubed solid dielectric container from a gas inlet 7, and blows off from the gas diffuser 5 as plasma by impressing pulse electric field between the electrode 2 arranged in the outside of a tubed solid dielectric container, and the inside electrode 3 arranged inside a tubed solid dielectric container. On the other hand, the circuit board 14 is carried with the carrying-in belt 41 at first, then, is carried by the gas diffuser with the processing belt 42, is processed, and consists of a conveyance process of three processes of subsequently being carried out by the taking-out belt 43. From the exhaust gas cylinder 10, gas [finishing / processing] is removed with the organic substance after processing, carries out the reattachment to the circuit board, and is not polluted. By using what can adjust delivery speed to arbitration, a conveyance belt can change extent of processing and

can also add cooling or a heating device further. moreover, the nozzle standby device in which it is made to stand by on the outside of a base material until the nozzle object which consists of a tubed solid dielectric performs a pre-discharge to inter-electrode after electrical-potential-difference impression and the plasma is stabilized if needed -- possession **** -- things can also be made, an X-Y-Z migration device can be made to be able to provide, and the sweep of the circuit board top can be carried out.

[0039] Drawing 8 is drawing showing an example of the equipment which sprays plasma gas on the circuit board by the parallel monotonous mold long nozzle, the equipment which prepared gas suction opening prepared in the perimeter of a gas diffuser nozzle, and equipment equipped with the conveyance device of the circuit board. 1 -- a power source, and 2 and 3 -- an electrode and 4 -- a solid dielectric and 5 -- in discharge space and 10, an exhaust gas cylinder and 14 express the circuit board, and 42 expresses [a gas diffuser and 7 / a raw gas inlet and 9] a conveyance belt, respectively. For example, raw gas is introduced in the direction of an arrow head from a gas inlet 7 in discharge space 9, and blows off from the gas diffuser 5 as plasma by impressing pulse electric field between an electrode 2 and an electrode 3. On the other hand, the circuit board 14 is carried by the gas diffuser with a belt 42, and is processed. From the exhaust gas cylinder 10, gas [finishing / processing] is removed with the organic substance after processing, and the reattachment of it is carried out to the circuit board, and it is not polluted. By using what can adjust delivery speed to arbitration, the conveyance belt 42 can change extent of processing and can also add cooling or a heating device further. moreover, the nozzle standby device in which it is made to stand by on the outside of the circuit board until a nozzle object performs a pre-discharge to inter-electrode after electrical-potential-difference impression and the plasma is stabilized if needed -- possession **** -- things can also be made, an X-Y-Z migration device can be made to be able to provide, and the sweep of the circuit board top can be carried out.

[0040] In processing of the circuit board of this invention, as gas for processing supplied to the above-mentioned solid-state dielectric inside of the body, processing of arbitration is possible and cleaning of the organic contamination of the circuit board, exfoliation of a resist, improvement of the adhesion of an organic film, reduction of a metallic oxide, and surface treatment can be performed for every purpose by selection of inert gas, such as oxygen, hydrogen, nitrogen, and an argon, etc.

[0041] For example, in manufacture of the circuit board, although an adhesive property will fall to the degree of pole if the object side of wire bonding is polluted with the organic substance like an epoxy resin, this can be cleaned by performing discharge plasma treatment, and wire-bonding reinforcement improves.

[0042] Moreover, although the metal terminal front face which solders is usually covered by the natural oxidation object, it can expose a pure surface of metal by performing plasma reduction processing of discharge plasma treatment for this to the bottom of hydrogen gas existence, and can raise adhesion with solder or a bonding wire.

[0043] Furthermore, discharge plasma treatment can be performed for front faces, such as the resin plate for the circuit boards, for example, a BGA resin plate etc., to the bottom of oxygen gas existence, and a surface organic contamination can be removed, and adhesion with closure resin can be raised by the hydrophilization by scaling.

[0044] When using gas other than inert gas as gas for processing from a viewpoint of economical efficiency and safety, it is desirable to process the gas for processing in

the ambient atmosphere diluted by inert gas. As inert gas, rare gas, such as helium, neon, an argon, and a xenon, a nitrogen gas, etc. are mentioned. These may be independent, or may mix and use two or more sorts. Although processing under existence of helium has been conventionally performed to the bottom of the pressure near the atmospheric pressure, according to the approach of impressing the electric field by which this invention was pulse-ized, it compares with helium and the stable processing in a cheap argon and a nitrogen gas is possible.

[0045] The mixing ratio of the gas for processing and inert gas is suitably determined by the class of gas to be used. What is necessary is just to determine a mixing ratio from a viewpoint of economical efficiency and safety, since it can process under the ambient atmosphere of the mixing ratio of arbitration when impressing pulse electric field. Since it will be hard coming to generate the discharge plasma if the concentration of the gas for processing is too high when not based on the pulse-ized electric field, as for the concentration of the above-mentioned gas for processing, it is desirable that it is 0.01 to 10 volume [in the mixed gas of the above-mentioned gas for processing and inert gas] %, and it is 0.1 to 5 volume % more preferably.

[0046] The above-mentioned gas for processing is made to discharge continuously in this invention from the gas diffuser 5 with which the above-mentioned solid dielectric container 4 was equipped. When using combining two or more kinds of gas for processing or diluting and using the gas for processing with inert gas, in the equipment of drawing 1 , each gas is mixed through the general quantity-of-gas-flow controller which is not shown all over drawing, and it is supplied in the above-mentioned solid dielectric container 4 from a gas inlet 7, and is made as [discharge / from the gas diffuser 5 / these mixed gas].

[0047] The above-mentioned gas for processing (when diluting and using with inert gas, the mixed gas of the gas for processing and inert gas is pointed out.) It is below the same. The amount of supply and the blowdown rate of flow are suitably determined by the cross section of the gas diffuser 5, the distance between the circuit board 14 and the gas diffuser 5, etc. For example, when the cross section of the gas diffuser 5 is 2 100mm, as the amount of supply of the gas for processing, flow rate 5SLM is desirable and rate-of-flow 830 mm/sec is desirable as a blowdown rate of flow of the gas for processing. When making the amount of supply of the gas for processing increase, in proportion to it, the blowdown rate of flow of the gas for processing increases, and the time amount which surface treatment takes is shortened.

[0048] It is not limited especially as a flow and pressure requirement which performs the discharge plasma treatment approach of this invention, but the processing under the pressure near the atmospheric pressure is possible. The bottom of the pressure near the atmospheric pressure points out the bottom of the pressure of 1.333x104 to 10.664x104Pa. Pressure regulation is easy and the range of 9.331x104 to 10.397x104Pa where equipment becomes simple is desirable.

[0049] The purpose of processing, the magnitude of applied voltage, the quality of the material of the circuit board, mixed-gas combination, etc. decide on the time amount which discharge plasma treatment takes suitably.

[0050] Moreover, where the circuit board is heated or cooled, it can process, or it can also process combining chemical pretreatment or after treatment.

[0051] Hereafter, the pulse electric field of this invention are explained. The example of a pulse voltage waveform is shown in drawing 9 . (Wave a) wave (b) is [a pulse mold and wave (d) of an impulse mold and wave (c)] the waves of a modulation mold. Although electrical-potential-difference impression mentioned what is the repeat of positive/negative to drawing 7 , the pulse of the type which impresses an

electrical potential difference to a forward or negative polarities [one of] side may be used. Moreover, the pulse electric field superimposed on the direct current may be impressed. The wave of the pulse electric field in this invention is not limited to the wave mentioned here, but may become irregular further using pulse shape, build up time, and the pulse from which a frequency differs. It is suitable for the above modulations performing high-speed continuation surface treatment.

[0052] The build up time and falling time amount of the above-mentioned pulse electric field are 40ns - 100 microseconds. If it exceeds 100 microseconds, that a discharge condition tends to shift to an arc, it will become unstable and will be hard coming to realize the stable discharge condition. Moreover, although ionization of the gas in the case of plasma generating is efficiently performed so that build up time and falling time amount are short, in less than 40ns, it is hard to realize on a facility. It is 50ns - 5 microseconds more preferably. In addition, as for the time amount whose electrical-potential-difference change is forward continuously, and falling time amount, as for build up time here, electrical-potential-difference change shall point out the time amount which is negative continuously.

[0053] The field strength of the above-mentioned pulse electric field is 1 - 100 kV/cm. Processing takes time amount too much as it is less than 1 kV/cm, and if 100 kV/cm is exceeded, it will become easy to generate arc discharge.

[0054] As for the frequency of the above-mentioned pulse electric field, it is desirable that it is 1kHz - 100kHz. Processing takes time amount too much as it is less than 1kHz, and if it exceeds 100kHz, it will become easy to generate arc discharge. Moreover, as for the time amount to which one pulse electric field are impressed, it is desirable that it is 1 microsecond - 1000 microseconds. Discharge becomes being less than 1 microsecond with an unstable thing, and if it exceeds 1000 microseconds, it will become easy to shift to arc discharge. It is 3 microseconds - 200 microseconds more preferably. Although the time amount to which the one above-mentioned pulse electric field are impressed has shown the example in drawing 7 R> 7, it means ON time amount in the pulse electric field which consist of a repeat of ON and OFF which one pulse follows.

[0055]

[Example] Although an example is hung up over below and this invention is explained to it in more detail, this invention is not limited only to these examples.

[0056] 1110(mm) x5mm(D) x -- plasma treatment of the following conditions was performed to the 100x100mm copper plate for the circuit boards using the plasma generator of drawing 8 which turns to a base material the plasma generated in the parallel monotonous mold inter-electrode to which specific inductive capacity carried out thermal spraying of the alumina system dielectric of 12 to 1mm thickness, and sprays it on the copper electrode of 50mm (H) from the gas diffuser nozzle 5 of the shape of a slit of 1mm spacing. [of examples W]

[0057] plasma treatment condition raw gas: -- mixed-gas discharge condition [of oxygen 0.5SLM+ argon 9.5SLM]: -- Wave a -- starting -- 10 microseconds of /falling time amount, the peak value of 4.5kV, the frequency of 10kHz, and the processing time -- 1 second [0058] As a result of analyzing the surface state of the copper plate before and behind processing in ESCA, the surface carbon component decreased from 62atom(s)% to 48atom(s)%. Moreover, the drop of the waterdrop of 2microL was carried out, and the static contact angle over the water on the front face of a copper plate before and behind processing was measured with the semi-automatic contact angle plan (consonance interface science company make, CA-X150). Consequently, after processing fell from 105 contact angles before processing to 20 degrees (getting

wet breadth condition). This showed that the surface organic contamination was removed.

[0059] Plasma treatment of the copper plate for the circuit boards was performed like the example 1 except having made the example 2 processing time into 3 seconds. As a result of analyzing the surface state of the copper plate before and behind processing in ESCA, the surface carbon component decreased from 62atom(s)% to 15atom(s)%. Moreover, the drop of the waterdrop of 2microL was carried out, and the static contact angle over the water on the front face of a copper plate before and behind processing was measured with the semi-automatic contact angle plan (consonance interface science company make, CA-X150). Consequently, after processing fell from 105 contact angles before processing to 10 degrees (getting wet breadth condition). This showed that the surface organic contamination was removed.

[0060] Plasma treatment of the copper plate for the circuit boards was performed like the example 1 except having made the example 3 processing time into 30 seconds. As a result of analyzing the surface state of the copper plate before and behind processing in ESCA, the surface carbon component decreased from 62atom(s)% to 5atom(s)%. Moreover, the drop of the waterdrop of 2microL was carried out, and the static contact angle over the water on the front face of a copper plate before and behind processing was measured with the semi-automatic contact angle plan (consonance interface science company make, CA-X150). Consequently, after processing fell from 105 contact angles before processing to 5 times (getting wet breadth condition). This showed that the surface organic contamination was removed.

[0061] 4250mm of examples (W) The plasma generator of drawing 8 which turns to a base material the plasma generated in the parallel monotonous mold inter-electrode to which specific inductive capacity carried out thermal spraying of the alumina system dielectric of 12 to 1mm thickness, and sprays it on the copper electrode of x5mm(D) x50mm(H) from the gas diffuser nozzle 5 of the shape of a slit of 1mm spacing is used. As a processed base material, plasma treatment was performed on the following plasma treatment conditions using the glass epoxy group plate of A4 size which 100 micrometers of diameters of beer and a pitch 250micrometer hole opened.

[0062] plasma treatment condition raw gas: -- mixed-gas discharge condition [of oxygen 30 volume %+CF42 volume %+ argon 68 volume %]: -- Wave a -- starting -- 10 microseconds of /falling time amount, 20kVPP, and the frequency [0063] of 10kHz The processing time is changed to 20sec(s), the amount of ** smears for every time amount (the amount of residue in a beer hall) is measured, and the result of having plotted the rate of a ** smear to the processing time is shown in drawing 10 R> 0. With the processing time, the rate of a ** smear was able to decrease and was able to remove the smear completely in 20 seconds.

[0064] It processed like the example 4 except having impressed the electrical potential difference with a frequency of 12.2kHz of a sin wave to the electrode, using the mixed gas of oxygen 1 volume %+CF40.5 volume %+ helium 98.5 volume % as example of comparison 1 raw gas. It took 10 minutes, although the rate of a ** smear becomes 20%, and even if it continued processing further, the rate of a ** smear was not able to be made 0%.

[0065] Under 21.333x10Pa of examples of a comparison, it processed like the example 4 except having impressed the electrical potential difference with a frequency of 12.2kHz of a sin wave to the electrode. It took 10 minutes, although the rate of a ** smear becomes 0%.

[0066] It used moving following discharge plasma treatment equipment as shown in drawing 1 equipped with the gas diffuser shown in example 5 drawing 4 , and plasma

treatment of the following conditions was performed to 100x100mm BGA for the circuit boards.
[0067] discharge plasma treatment equipment: -- 110mm(W) x5mm(D) x -- the solid dielectric container 4 of 50mm (H) is that to which specific inductive capacity carried out thermal spraying of the alumina system dielectric of 12 to the inside of a copper container at 1mm thickness, a gas inlet 7 and the gas diffuser 5 of the shape of a 100mm wide and 1mm long slit are formed, and the 100x30x1mm copper electrode 2 is arranged by about five gas diffuser. Moreover, another 100x30x1mm copper electrode 3 maintains an electrode 2 and spacing of 10mm at the rear face of a sample 14, and is arranged in it.
[0068] plasma treatment condition raw gas: -- mixed-gas discharge condition [of oxygen 1SLM+ argon 9SLM]: -- Wave a -- starting -- 10 microseconds of /falling time amount, the peak value of 7.2kV, the frequency of 10kHz, and the processing time -- 5 seconds [0069] As a result of analyzing the surface state of BGA for the circuit boards before and behind processing in ESCA, the surface carbon component decreased from 75atom(s)% to 10atom(s)%. Moreover, the drop of the waterdrop of 2microL was carried out, and the static contact angle over the water on the front face for the circuit boards of BGA before and behind processing was measured with the semi-automatic contact angle plan (consonance interface science company make, CA-X150). Consequently, after processing fell to 0 degree (getting wet breadth condition), and 105 degrees of contact angles before processing showed that hydrophilization was carried out.
[0070] Next, BGA for the circuit boards before and behind processing was closed using the molding resin for semi-conductors, and the adhesion reinforcement of a substrate and closure resin was measured as a value of shear peel strength. Consequently, the adhesion reinforcement before processing improved from 8MPa(s) to 15MPa(s). This shows that the surface organic contamination was removed by discharge plasma treatment, and adhesion improved by the hydrophilization by scaling.
[0071] It used moving the same discharge plasma treatment equipment as example 6 example 4, and plasma treatment of the following conditions was performed to the 100x100mm copper plate for circuits. plasma treatment condition raw gas: -- mixed-gas discharge condition [of hydrogen 0.5SLM+ argon 9.5SLM]: -- Wave a -- starting -- 10 microseconds of /falling time amount, the peak value of 5.5kV, the frequency of 10kHz, and the processing time -- 5 seconds [0072] As a result of analyzing the surface state of the copper plate before and behind processing in ESCA, it turned out that the surface oxygen component decreased from 40atom(s)% to 15atom(s)%, and the reduction reaction progressed. Next, the gold wire was soldered to the copper plate before and behind processing, and the wire tensile strength by soldering was measured by the tension test with a spring balance. Consequently, the tensile strength before processing improved from 9g to 11g.
[0073] Although processed like the example 1 except having impressed the electrical potential difference with a frequency of 12.2kHz of a sin wave instead of example of comparison 3 pulse electric field, the electrical potential difference required for discharge generating required 10kV or more, since the discharge condition was arc discharge, the processing substrate dissolved and the hole opened.
[0074] It processed like the example 2 except having impressed the electrical potential difference with a frequency of 12.2kHz of a sin wave instead of example of comparison 4 pulse electric field. Since a processed material was a metal, although breakdown voltage was about 7kV, it became arc discharge too and the copper

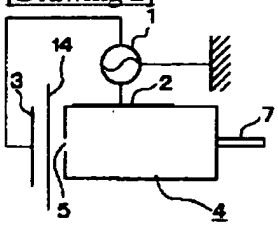
substrate front face fused it.
[0075]
[Effect of the Invention] The discharge plasma treatment approach of this invention consists of an above-mentioned configuration, and can carry out continuous surface treatment of the circuit board, partial surface treatment, etc. to homogeneity by simple equipment and the little gas for processing under atmospheric pressure. Moreover, since-izing of the surface treatment process can be carried out [in-line] easily, it is also possible to be able to clean a circuit board front face easily and to reform an adhesive property and printing nature easily. Moreover, range of the discharge plasma treatment approach of this invention, such as electrical-potential-difference conditions that the discharge condition which could perform processing stabilized on advanced level under the atmospheric-pressure condition, and was stabilized is realizable, is also wide by generating the discharge plasma by impressing specific pulse electric field. Furthermore, according to the specific pulse electric field by this invention, the discharge plasma of high density can be generated and it is advantageous in high-speed consecutive processing.

CLAIMS

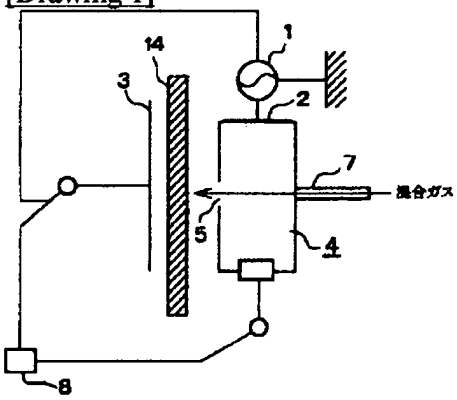
[Claim(s)]
[Claim 1] The discharge plasma treatment approach of the circuit board characterized by contacting the plasma acquired by installing a solid dielectric in one [at least] opposed face of the electrode of the pair which counters, introducing raw gas between the counterelectrodes of the pair concerned, and impressing pulse-like electric field under the pressure near the atmospheric pressure to the circuit board.
[Claim 2] The discharge plasma treatment approach according to claim 1 that a pulse standup and/or falling time amount are characterized by pulse-like electric field being [100 or less microseconds and field strength] 1 - 250 kV/cm.
[Claim 3] The discharge plasma treatment approach of the circuit board according to claim 1 or 2 that a frequency is characterized by pulse-like electric field being [0.5-100kHz and pulse length] 1 - 1000 microseconds.
[Claim 4] The discharge plasma treatment approach given in any 1 term of claims 1-3 characterized by being made as [draw / the plasma generated between counterelectrodes / from a gas diffuser nozzle / toward a base material].
[Claim 5] Arrange the solid dielectric container which equipped the electrode of 1 with the gas diffuser, make the gas diffuser concerned counter, and other electrodes are prepared. At the same time it arranges the circuit board between the gas diffuser concerned and other electrodes and makes the gas for processing discharge continuously from the gas diffuser concerned It is the discharge plasma treatment approach of generating the discharge plasma by impressing electric field to inter-electrode. the electrode concerned of 1 -- being concerned -- others -- The discharge plasma treatment approach that it is characterized by the pulse-like electric fields impressed to inter-electrode being build up time, the falling time amount for 100 or less microseconds, and the field strength of 1-100kV/cm.
[Claim 6] The discharge plasma treatment approach given in any 1 term of claims 1-5 to which the circuit board is characterized by being a resin plate for the circuit boards.
[Claim 7] Discharge plasma treatment equipment for circuit board processing characterized by coming to have the device which introduces raw gas between the

counterelectrode of a pair with which the solid dielectric was installed in one [at least] opposed face, and the counterelectrode of the pair concerned, the device in which pulse-like electric field are impressed to this inter-electrode one, and the device in which the plasma acquired by this pulse electric field is contacted to the circuit board.
[Claim 8] Discharge plasma treatment equipment according to claim 7 characterized by being made as [draw / the plasma to which the device in which the circuit board was made to contact generated the plasma between counterelectrodes / from a gas diffuser nozzle / toward a base material].
[Claim 9] the electrode of 1 with which the solid dielectric container equipped with the gas diffuser was arranged -- and Have other electrodes which countered the gas diffuser concerned and were prepared, and it is made as [make / the gas for processing / discharge continuously from the gas diffuser concerned]. the electrode concerned of 1 -- being concerned -- others -- the discharge plasma treatment equipment for processing characterized by being made as [impress / to inter-electrode / the pulse-like electric field build up time and whose falling time amount are 100 or less microseconds and, whose field strength is 1 - 100 kV/cm].
[Claim 10] Discharge plasma treatment equipment according to claim 9 characterized by the specific inductive capacity [container / solid dielectric] under 25-degree-C environment consisting of the ten or more quality of the materials.

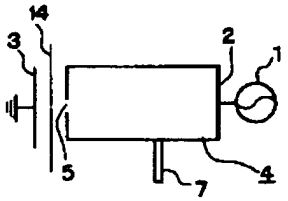
[Drawing 2]



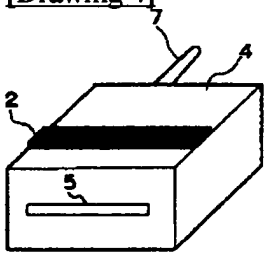
[Drawing 1]



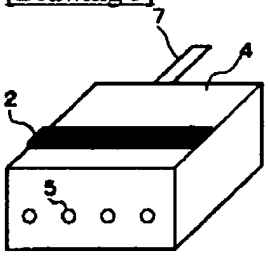
[Drawing 3]



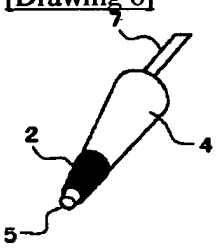
[Drawing 4]



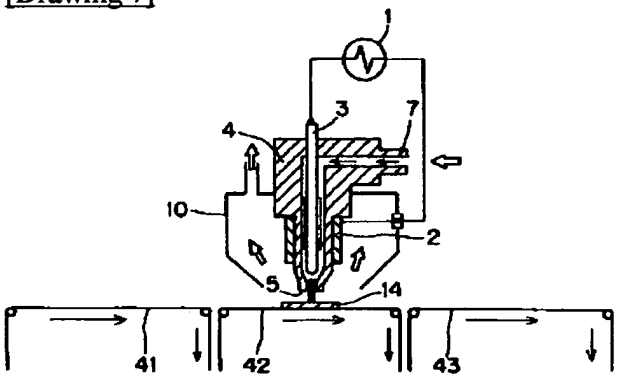
[Drawing 5]



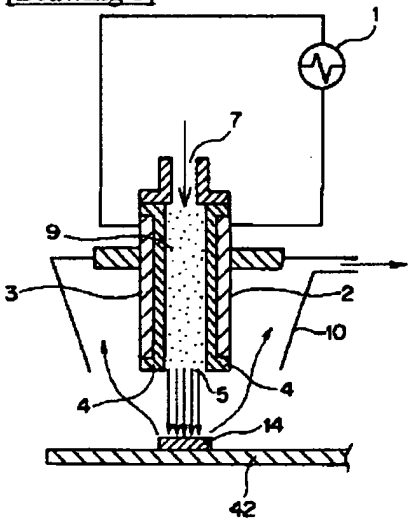
[Drawing 6]



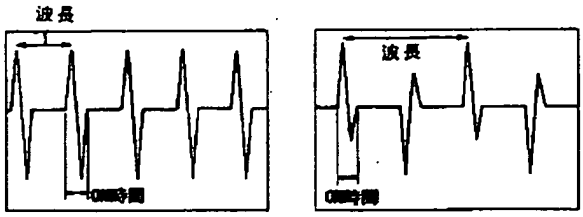
[Drawing 7]



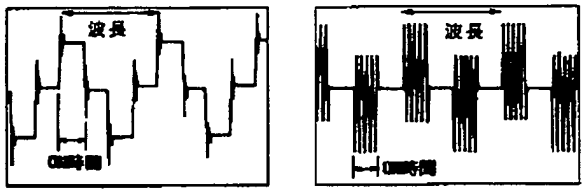
[Drawing 8]



[Drawing 9]



波形(a)　　波形(b)



波形(c)　　波形(d)

[Drawing 10]